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BROADBAND GROUNDED VERTICAL ANTENNAS FOR 30-180 MHZ (VHF)

STATEMENT OF GOVERNMENT INTEREST

[0001] The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

CROSS REFERENCE TO OTHER PATENT APPLICATIONS

[0002] None.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0003] The present invention is generally directed towards antennas with a broad frequency range to act as either a source antenna (transmitting signals) or a receive antenna (receiving signals), with a known gain value. More specifically, the invention is directed towards an antenna design that is separated into two variant antennas; one to cover the 30-60 MHz range and one to cover the 60-180 MHz range.

(2) Description of the Prior Art

[0004] There is often a need for antennas with broad frequency ranges. A starting point for such antennas is the grounded quarter wave monopole antenna. The grounded quarter wave monopole (quarter-wavelength whip above a ground plane) is a

resonant structure. A separate antenna design, the cone element antenna, is a broadband radio frequency (RF) radiator. Each design offers important capabilities for RF transmission and reception. What is needed is a combination of the capabilities of resonant structure with a broadband RF radiator coupled with an ability to implement impedance matching and to affect desired antenna patterns.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to provide a combination of two very different yet simple antenna elements: the grounded quarter wave monopole (quarter-wavelength whip above a groundplane) which is a resonant structure, and the cone element which is a broadband radio frequency (RF) radiator, lest the antenna only be well-matched at one particular frequency (at the frequency where the element is one quarter-wave long)

[0006] It is also an object of the present invention to provide an antenna with broad frequency range to act as either source antenna or receive antenna, with a known gain value.

[0007] It is also an object of the present invention to provide an antenna that is broadband in frequency so that no matching or physical tuning is necessary, allowing for straightforward testing

[0008] The above and other objects and advantages of the present invention will become apparent in view of the following description, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a diagram of the design a preferred embodiment of the antenna of the present invention for use in the 30-60 MHz range;

[0010] FIG. 2 is a graph of the antenna standing wave ratio in the 30-60 MHz frequency range.

[0011] FIG. 3 is a graph of the Antenna Realized Gain in the 30-60 MHz frequency range.

[0012] FIG. 4 is a diagram of the design of an alternative preferred embodiment of the antenna of the present invention for use in the 60-180 MHZ range;

[0013] FIG. 5 is a graph of the antenna standing wave ratio in the 60-180 MHz frequency range.

[0014] FIG. 6 is a graph of the Antenna Realized Gain in the 60-180 MHz frequency range.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0015] Referring to FIG. 1, the antenna 10 is assembled from the following components starting from the bottom there is a ground plane 22 made of a conductive material such as aluminum.

In a preferred embodiment, the ground plane 22 is one square meter in dimensions. Connected to the ground plane 22 is the antenna base 12. Connected to the base 12 is a wired RF connector 14 (e.g. N-type), having an RF center conductor and an RF ground conductor. Attachment hardware 16 (e.g. bolts) are used to attach the base 12 to the ground plane 22. A dielectric base spacer 18 (e.g. fiberglass) is connected to a lower conductive cone element 20 and the base 12. In a preferred embodiment lower cone element 20 is twenty four inches in length. A second dielectric spacer, the upper spacer 24, is connected to an upper conductive cone element 26. In a preferred embodiment upper cone element 26 is twenty four inches in length. Finally, a linear conductive antenna element (whip) 28, is connected to the conductive cone element 26. In a preferred embodiment, the linear element 28 is one meter in length.

[0016] The ground for the antenna 10 can be any ground surface, typically dirt, metal, or seawater. The ground plane 22, being the bottom of the antenna 10, is placed on top of the ground to produce a vertical, electrically-polarized antenna. It is recommended that the general ground be capable of conducting electricity and be electrically connected to ground plane 22. Although the antenna base 12 is not strictly necessary it is preferred design element. Regardless of whether

there is an antenna base 12 or not, there must exist a high-quality electrical bond between the RF ground conductor of the RF connector 14 and the ground plane 22 to permit flow of RF ground currents. The RF center conductor of the RF connector 14 must have a high-quality electrical bond to the lower conductive cone element 20. The base spacer 18 is used as a mechanically-robust spacer to hold up the antenna 10 as well as electrically separate the ground plane 22 and the antenna base 12 from the lower conductive cone element 20. The upper spacer 24 is used as a mechanically-robust spacer to support the upper cone element 26. The upper cone element 26 must have a high-quality electrical bond to the lower cone element 20. The linear conductive antenna element 28 is mechanically attached to the upper cone element 26 with a high-quality electrical bond. In combination with both the upper and lower cone elements 26 and 20, the linear conductive antenna element 28 produces a desirable current distribution and antenna pattern across the frequency range of interest. In summary, the lower conductive cone element 20, the upper conductive cone element 26, and the linear element 28 are electrically connected to the RF center conductor of wired RF connector 14. The ground plane 22 and the antenna base 12 are electrically connected to the RF ground conductor of the RF connector 14. The antenna design is intended to maintain electrical separation between the RF center

and the RF ground of RF connector 14. The high-quality electrical bond provides low resistance and short electrical length so as to practically be invisible to the antenna's performance.

[0017] The lower cone element 20, upper cone element 26 and linear element 28 act in concert with the ground plane 22 to produce an antenna pattern with a strong low-angle lobe omni-azimuthally. The ground plane 22 is large enough and the frequency band low enough that using a square ground plane still allows for an omni-azimuthal pattern. The antenna impedance is partially affected by the general ground and any conductive elements nearby. As illustrated in FIG. 2, its standing wave ratio (SWR) is predominantly less than 4:1 across the band when the ground is seawater and would be similar for other grounds. The antenna pattern will also be partially affected by the ground and any conductive elements nearby illustrated in FIG. 3, it produces a far-field realized gain for low angles (0-15°) of roughly 1-5 dBi when over seawater. In general, for the ground being of shorter lengths and of lower conductivity materials, the realized gain and SWR will worsen—the realized gain could significantly deviate from that of FIG. 3. Note that FIG. 2 and FIG. 3 reflect measured values, which are supported by predictions.

[0018] Referring to FIG. 4 there is illustrated the design of an alternative preferred embodiment of the antenna of the present invention for use in the 60-180 MHZ range, the antenna 40 is assembled from the following components starting from the bottom there is a ground plane 52 made of a conductive material such as aluminum. In a preferred embodiment, the ground plane 52 is one square meter in dimensions. Connected to the ground plane 52 is the antenna base 42. Connected to the base 42 is a wired RF connector 44 (e.g. N-type), having an RF center conductor and an RF ground conductor. Attachment hardware 46 (e.g. bolts) are used to attach the base 42 to the ground plane 52. A dielectric base spacer 48 (e.g. fiberglass) is connected to a conductive cone element 50 and the base 42. In a preferred embodiment the cone element 50 is twenty four inches in length. Finally, a linear conductive antenna element (whip) 54, is connected to the conductive cone element 50. In a preferred embodiment, the linear element 54 is one meter in length.

[0019] The antenna 40 is positioned on the general ground which could be solid earth or a metal surface or seawater. The ground plane 52, being the bottom of the antenna 40, is placed on top of the ground to produce a vertical, electrically-polarized antenna. It is recommended that the general ground be capable of conducting electricity and be electrically connected to ground plane 52. Although the antenna base 42 is not strictly

necessary it is preferred design element. Regardless of whether there is an antenna base 42 or not, there must exist a high-quality electrical bond between the RF ground conductor of the RF connector 44 and the ground plane 52 to permit flow of RF ground currents. The RF center conductor of the RF connector 44 must have a high-quality electrical bond to the conductive cone element 50. The dielectric spacer 48 is used as a mechanically-robust spacer to hold up the antenna 40 as well as electrically separate the ground plane 52 and the antenna base 42 from the conductive cone element 50. The linear conductive antenna element 54 is mechanically attached to the cone element 50 with a high-quality electrical bond. In combination with the cone element 50, the linear conductive antenna element 54 produces a desirable current distribution and antenna pattern across the frequency range of interest. In summary, the conductive cone element 50 and the linear element 54 are electrically connected to the RF center conductor of wired RF connector 44. The ground plane 52 and the antenna base 42 are electrically connected to the RF ground conductor of the RF connector 44. The antenna design is intended to maintain electrical separation between the RF center and the RF ground of RF connector 44. The high-quality electrical bond provides low resistance and short electrical length so as to practically be invisible to the antenna’s performance.

[0020] The conductive cone element 50 and the linear antenna element 54 act in concert with the ground plane 52 to produce an antenna pattern with a strong low-angle lobe omni-azimuthally. The pattern is very similar to that of an ideal quarter-wave monopole across its frequency range. The ground plane 52 is large enough and the frequency band low enough that using a square ground plane still allows for an omni-azimuthal pattern. The antenna impedance of antenna 40 is partially affected by the ground upon which it is situated, as well as any conductive elements nearby. As illustrated in FIG. 5, the standing wave ratio (SWR) of antenna 40 is predominantly less than 3:1 across the band when the ground is seawater or conductive metal and would be similar for other grounds. The antenna pattern of antenna 40 will also be partially affected by the ground and any conductive elements nearby. As illustrated in FIG. 6, antenna 40 produces a far-field realized gain for low angles (0-15°) of roughly 1-7 dBi when 1” above seawater. In general, for the ground being of shorter lengths and of lower conductivity materials, the realized gain and SWR will worsen—the realized gain could significantly deviate from that of FIG. 6.

[0021] The grounded quarter wave monopole is a de facto standard of antenna measurements. Its gain and impedance are well-described in theory and practice. However, practical measurements are confined to one frequency point at a time.

Multiple frequency points require either tuning the length to the proper dimension to achieve each quarter-wavelength resonance or the use of a broadband matching network. By expanding the quarter wave monopole to a broadband design with zero matching network necessary, the antenna no longer needs to be physically re-tuned (time) or a matching network (losses and extra component), with the advantage of still being based on the grounded monopole theory. Conical antennas are well known for their broadband gain (monocone, bicone) but are never combined with a monopole. An eccentric combination of broadband and resonant structures that when paired appropriately are very effective, as has been proven here by the present invention.

[0022] Other broadband antennas may exist but do not have the desired features for the specific application. In this case, interaction with a ground plane is very important as the antenna is designed for interaction with a larger ground plane than is designed into the antenna itself, as electric antennas (as opposed to magnetic) have strong interaction with nearby conductive materials.

[0023] In a preferred embodiment, antenna 10 and 40 are constructed out of aluminum, but as with any electric antenna, the construction is a tradeoff of mechanical (robustness, resistance to corrosion) and electrical properties (efficiency). The cone elements', whip's, and ground plane's shape and dimensions affect

antenna pattern, radiation efficiency, and impedance; dimensional and shape changes will maintain the principle of this antenna but will alter the RF performance.

[0024] Advantages of the present invention include because this antenna design is broadband in frequency, no matching or physical tuning is necessary, allowing for straightforward testing. The antennas 10 and 40 are designed for vertically-polarized electric fields at/on a general ground surface with the antenna pattern being omni-azimuthal up to 15° above the horizon and predominantly less than 4:1 standing wave ratio across the band. The antennas 10 and 40 utilizes simple elements, a combination of one or two cone elements and a linear whip on top a square ground plane, to achieve desired performance across their frequency band.

[0025] The foregoing description of the preferred embodiments of the invention has been presented for purposes of illustration and description only. It is not intended to be exhaustive or to limit the invention to the precise form disclosed; and obviously many modifications and variations are possible in light of the above teaching. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of this invention as defined by the accompanying claims.

BROADBAND GROUNDED VERTICAL ANTENNAS FOR 30-180 MHZ (VHF)

ABSTRACT OF THE DISCLOSURE

The invention is an antenna with broad frequency range to act as either source antenna (transmitting signals) or receive antenna (receiving signals), with a known gain value. The antenna is separated into two variant antennas: one to cover 30-60 MHz and one to cover 60-180 MHz. Because this antenna is broadband in frequency, no matching or physical tuning is necessary, allowing for straightforward testing. The antenna is designed for vertically-polarized electric fields at/on a general ground surface with the antenna pattern being omni-azimuthal up to 15° above the horizon and predominantly less than 4:1 standing wave ratio across the band. The antenna utilizes simple elements to achieve desired performance across its frequency band: a combination of one or two cone elements and a linear whip on top of a square ground plane.

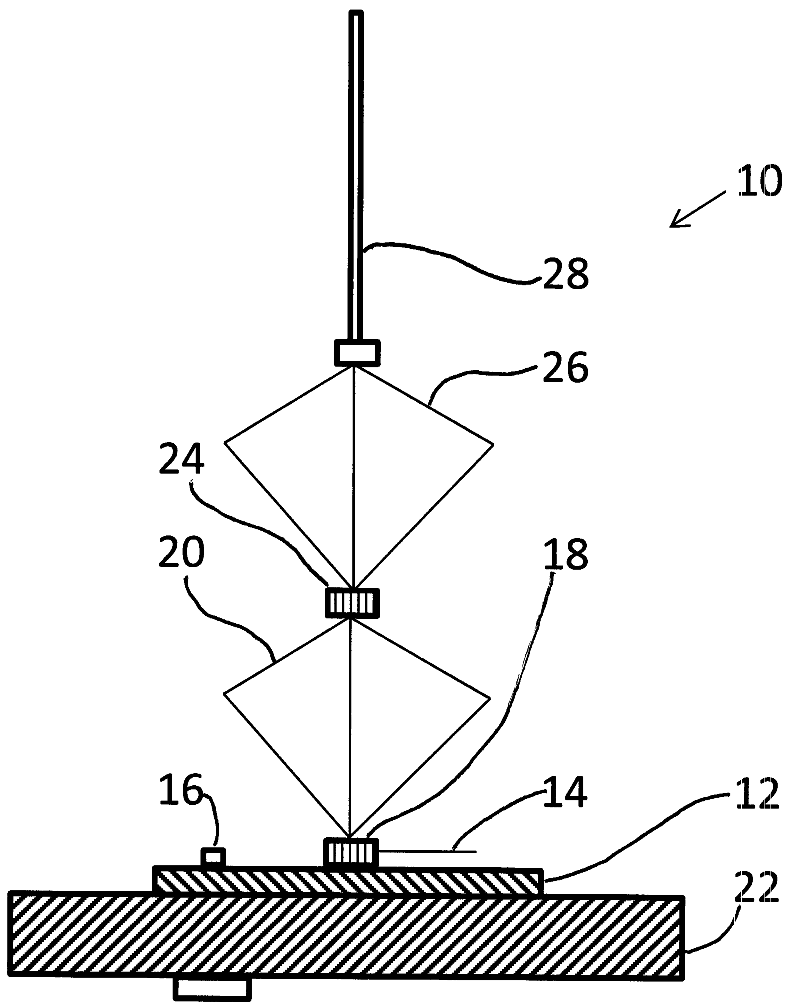
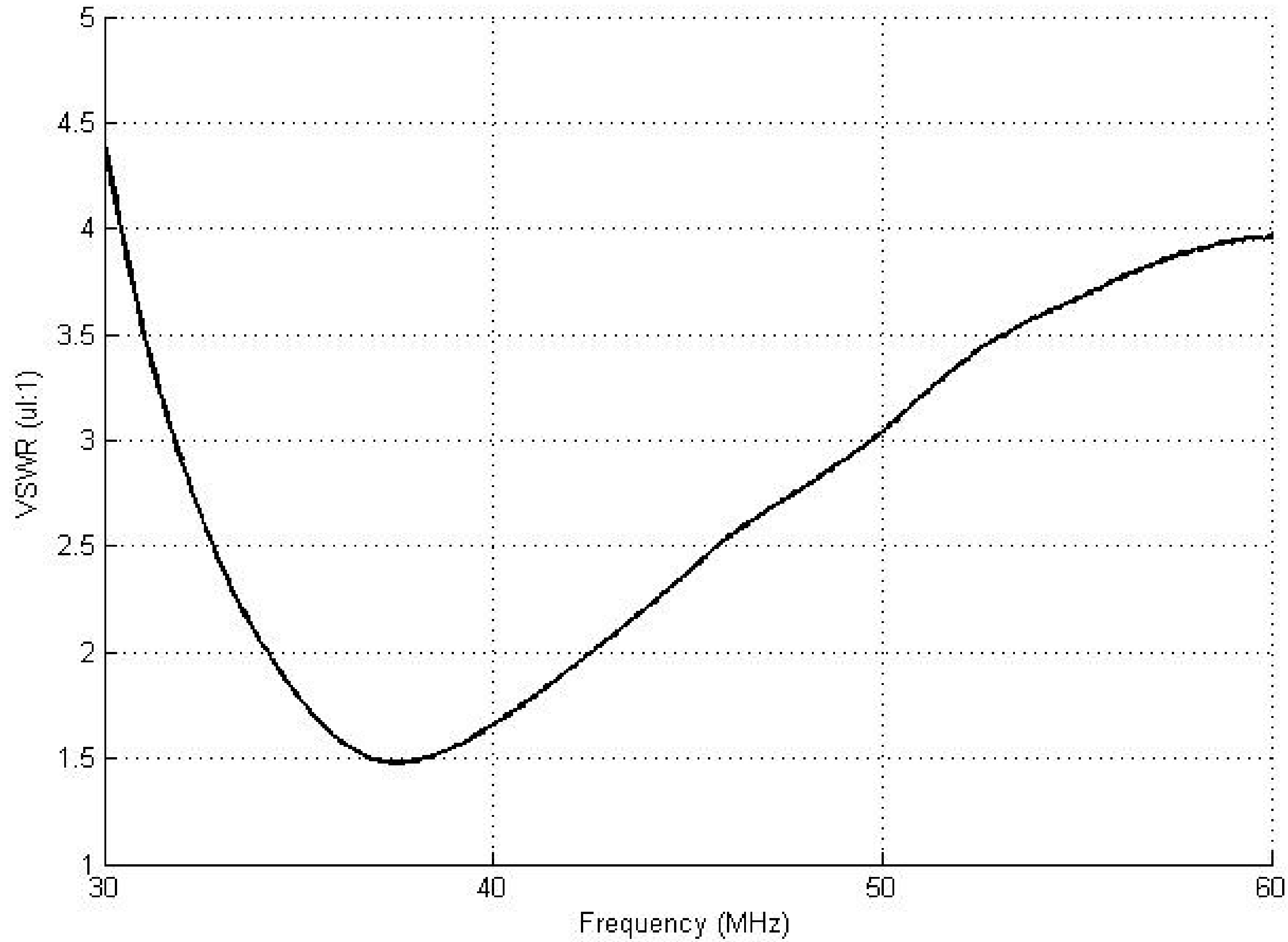
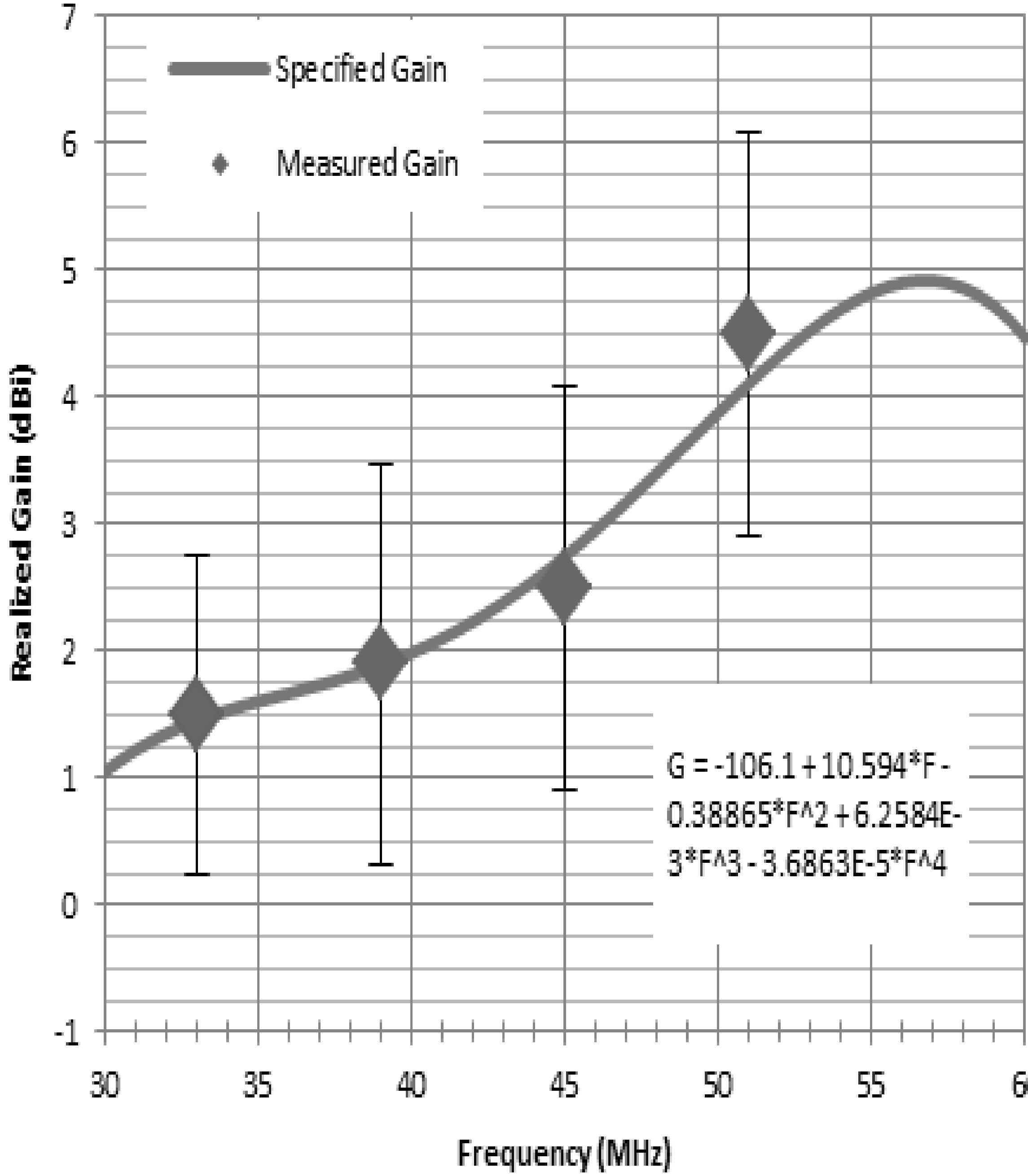


FIG. 1



Antenna SWR (Seawater General Ground) (30-60 MHz)

FIG. 2



Antenna Realized Gain (Seawater General Ground) (30-60 MHz)

FIG. 3

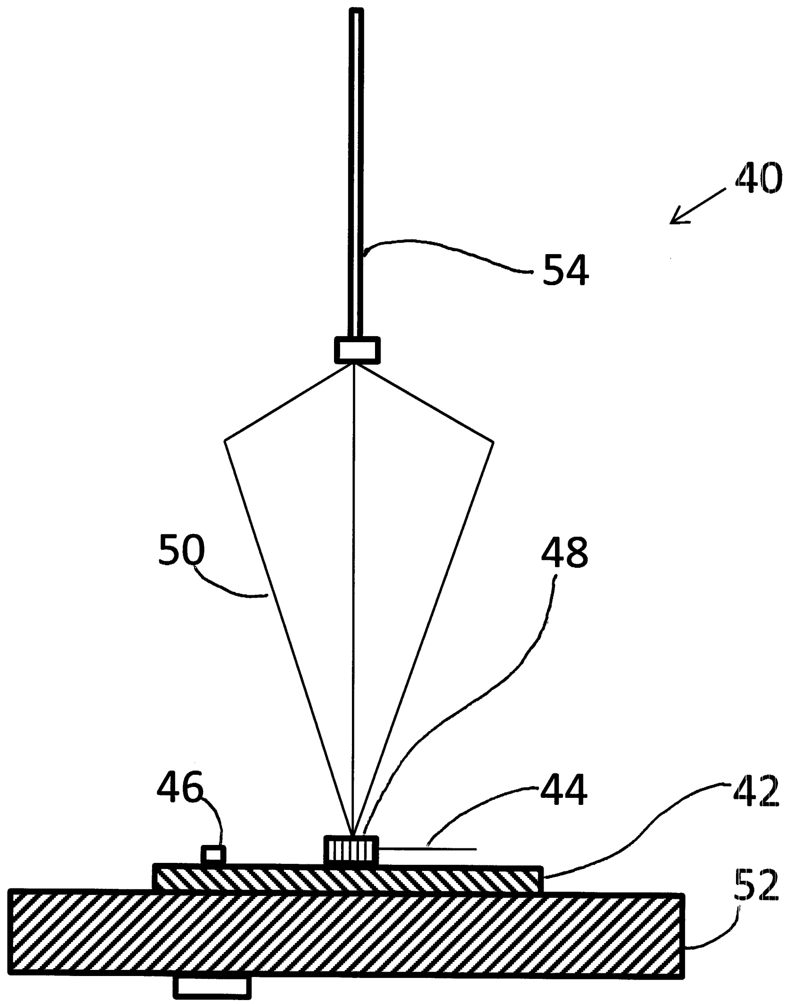
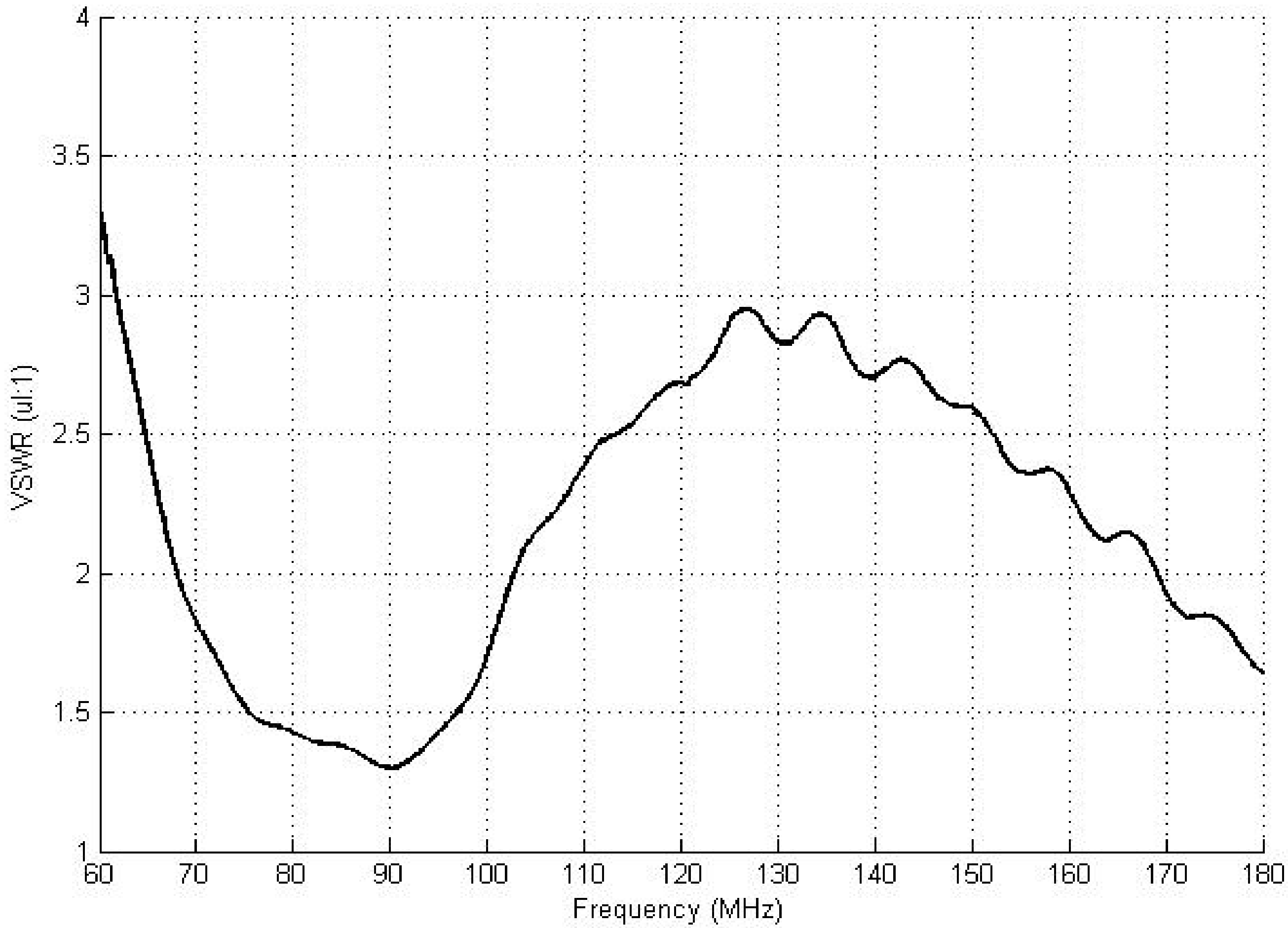
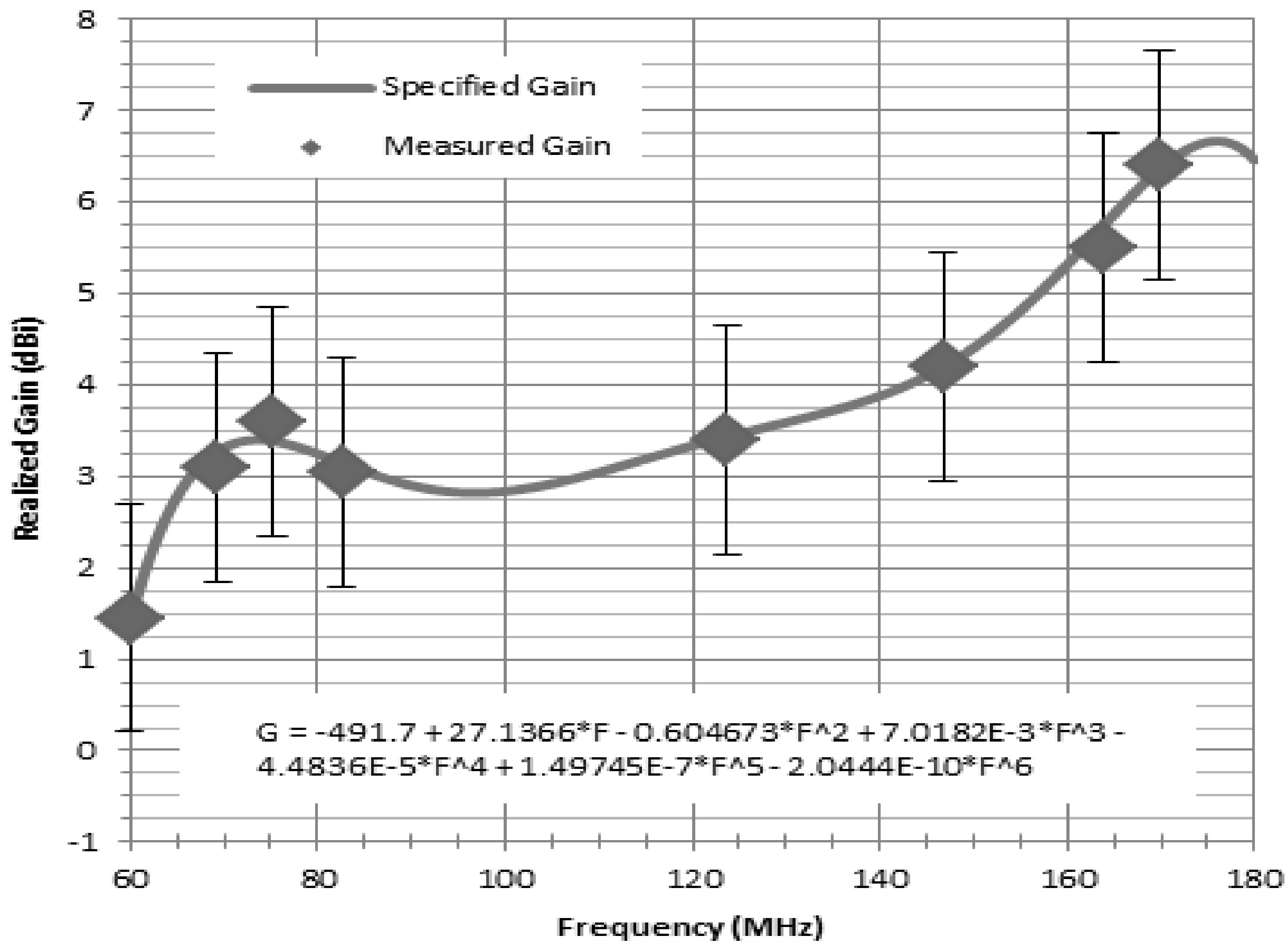


FIG. 4



Antenna SWR (Seawater or Metal General Ground) (60-180 MHz)

FIG. 5



Antenna Realized Gain (1" Above Seawater General Ground) (60-180 MHz)

FIG. 6